Autonomous Bio-Optical Instruments

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LONG-TERM GOALS

Our long-term goal is to understand the biogeochemical dynamics of the ocean's upper kilometer. Such an understanding is fundamental to prediction of the processes partitioning carbon between atmosphere and ocean and to the redistribution of carbon and associated elements within the water column. Key to predictability is understanding the day-to-day variability of processes governing abundances of carbon species (dissolved and particulate, inorganic and organic) in the water column.

OBJECTIVES

Our objective is to demonstrate the concept of low-cost autonomous profiling vehicles outfitted with a suite of low-power optical, physical and chemical sensors. When widely deployed, these will permit high-frequency four-dimensional observations of the variability of ocean biological processes, carbon biomass, upper ocean physics, and parameters of the carbon system in the upper 1000 m. It is envisioned that once proven, such vehicles can be widely deployed to explore carbon variability on global scales. An immediate objective is to demonstrate that we can explore Particulate Organic Carbon and Particulate Inorganic Carbon biomass variability in the water column on daily to seasonal time-scales in remote and extreme environments.

APPROACH

Platform. The Sounding Oceanographic Lagrangian Observer (SOLO; Davis et al., 2001), a low-cost, long-lived autonomous profiling float is used to profile sensors vertically through the upper kilometer. SOLO is well-proven platform for physical measurements. It has been augmented with new optical sensors for biogeochemistry that permit the rapid and precise determination of two important products of photosynthesis, Particulate Organic Carbon (POC) and Particulate Inorganic Carbon (PIC), along with physical data (T, S and derived density stratification) relevant to understanding the variability of POC and PIC. SOLO has been being modified to accommodate POC and PIC sensors and ORBCOMM transceivers for bi-directional satellite telemetry of data at much higher data rates than was possible with the previously used System Argos.

Implementation of faster telemetry permits transmission of data from the expanded sensor suite while significantly reducing the time (and hence susceptibility to biofouling) of the float in the surface layer. SIO leads the modification of SOLO preparation of floats for sea. Testing of the integrated float/sensor package is a joint effort of LBNL and SIO. LBNL is responsible for calibration and data reduction.

POC sensor. Bishop (1999) and Bishop et al. (1999) have shown that beam attenuation at 660 nm is strongly correlated to POC in open ocean waters. WETLabs is responsible for providing a stable and precise transmissometer (beam attenuation stable to better than 0.001 m^{-1}) for accurate long-term high-frequency measurement of POC in the upper kilometer.

PIC sensor. Particulate inorganic carbon is mostly in the form of calcite. LBNL has investigated the optical properties (e.g. refractive index, birefringence ...) of calcite and is working with WETLabs to develop and implement a transmission type sensor to quantify calcite suspensions.

WORK COMPLETED

New SOLO electronics were built and tested to handle temperature, conductivity, pressure and up to four optical channels. A combined antenna was developed for ORBCOMM satellite communication and GPS navigation. A new SOLO controller coordinates a mission (profiling, navigating, measuring and data relay) and handles two-way ORBCOMM communication. The latter is key to enabling sophisticated and adaptive sampling.

Engineering sea trials, conducted in November 2000 and February 2001, confirmed functionality of the more powerful SOLO configuration and comparability of the optical measurements made from solo with well-proven shipboard measurements.

Two SOLOs were deployed in the North Pacific near Ocean Weather Station P (50^{o} N, 145^{o} W) in April 2001. Each outfitted with a Wetlab transmissometer for measuring POC and a Seapoint backscattering sensor that we wish to compare with transmission measurements.

RESULTS

The floats deployed at OWS P have now completed over 180 cycles each. Mission parameters (such as profile depth and ascent/descent timing) have been successfully modified from shore via satellite telemetry, allowing adaptive mission programming to meet the scientific objectives. Data loss has averaged 0.02%, due mainly to poor communications during storm conditions. Stormy weather has also resulted in loss of GPS location fixes on 6% of the opportunities. A more robust data communication algorithm has been implemented for a third NOPP SOLO, which was recently deployed for a two week test. A more robust GPS system will be an objective of future work.

IMPACT/APPLICATIONS

The sensors and methodology employed in this project can easily migrate to other autonomous platforms; furthermore, the work of this partnership will lay the foundation for expanded sensor suites and their integration onto recoverable autonomous self-navigating platforms designed to quantify both the reactants and products of photosynthesis, and the rates of carbon-system processes.

TRANSITIONS

None as yet.

REFERENCES

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